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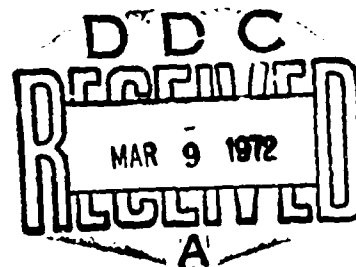
THE COMPARATIVE EFFECTIVENESS OF
FOUR RIOT CONTROL AGENTS

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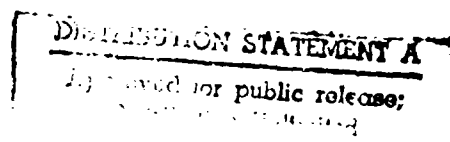
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Directorate of Medical Research
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In conducting the research described in this report, the investigators adhered to humane animal experimental procedures.

The volunteers in these tests were handled in accordance with principles, policies, and rules analogous to those established in AR 70-25.



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THE COMPARATIVE EFFECTIVENESS OF
FOUR RIOT CONTROL AGENTS (U)

(U) The need of dispelling riotous mobs without causing casualties has led to the study of several chemical substances which have harassing or incapacitating properties when inhaled.

(C) This report includes data on the inhalation toxicity in laboratory animals and the tolerable or incapacitating dosage in man of CN, DM, EA 1778, and EA-1779.

(C) Toxicity determinations were conducted on the mouse, rat, and guinea pig by exposing them to the agents for various periods of time, ranging from 15 to 60 minutes at concentrations from 50 to 4000 mg./m³. Periodic samples of the chamber atmosphere were analyzed for airborne concentrations. The toxicity of inhaled riot control agents for laboratory animals is summarized in Table 1.

TABLE 1 (C)
Toxicity of Inhaled Riot Control Agents
Expressed Dose x 1000 = mg.min./m³

Agent	Species	LC ₅₀ *	Minimum Lethal Dose
DM	Mouse	30	1
	Rat	3	1.2
	Guinea Pig	8.5	3.5
EA 1778	Mouse	45	28
	Rat	60	15
	Guinea Pig	20	10
EA 1779	Mouse	35	22
	Rat	18	6.7
	Guinea Pig	8.8	6.9
CN	Mouse	0.8	0.4

*Multiply all values by 1000

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(U) The human exposures were made in two phases. In the first

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phase, the subjects were allowed to breathe the agent from a 200 liter dynamic flow chamber through a face mask so that the eyes, nose, and mouth were exposed to the aerosol or vapor. By this technique we attempted to establish a concentration of the agent which would be intolerable. The second phase of the experiment consisted of total body exposures of the volunteers in a 20 m³ chamber.

(U) In both sets of experiments the same instructions applied: the volunteers kept on the gas mask, or remained in the chamber, until the exposure became intolerable. When, in their judgment, the intolerable level was reached, they were free, without any prompting from the observers, to take off the face mask or to leave the chamber, as the case may be. If, however, the volunteers were able to tolerate the agents for an indefinite period of time, the exposure was terminated at a predetermined time which would not exceed the maximum allowable concentration as setup for this experiment. Samples of the atmosphere for analysis were taken during each exposure to determine the actual intolerable level for each subject.

(U) Each volunteer had a complete history and physical examination including a chest X-ray. Any person with a history of any allergy or pulmonary pathology was not used in the experiment.

(U) After each exposure, the subjects were questioned and re-examined. In the total exposures in the large chamber the airway resistance was measured using an Archrometer¹. The post-exposure values were compared to control values taken just prior to exposure.

¹Instrument developed by Dr. J. Clements, USA CWL, Directorate of Medical Research.

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(U) The effect of individual riot control agents in man is shown in Table 2.

TABLE 2 (C)

Effect of Riot Control Agents on Man
The Results Summarize Both Sets of Observation

Concentration		DM	CN	EA 1778	EA 1779
Min	Max				
mg./m ³ *		Number Deciding the Agent Intolerable Within 30 Sec.			
2	10	0/10	0/4	0/9	2/15
11	20	0/11	0/1	0/14	3/6
21	50	0/4	0/8	9/39	10/10
51	100	0/1	0/24	-	12/10
101	360	-	3/12	-	-
		Number Deciding the Agent Intolerable Within 120 Sec.			
2	10	0/10	0/4	0/9	6/15
11	20	1/11	1/1	7/14	5/6
21	50	0/4	2/8	20/39	10/10
51	100	1/1	3/24	-	12/12
101	360	-	9/12	-	-
		Persistence of the Incapacitating Signs - Min.			
		20 to 120	1 to 10	1	5 to 20
		Time to Incapacitation - Sec.			
		90 to 180	25 to 300	10 to 180	6 to 60

*(C) Based on the molecular weight of these compounds 1 ppm is equivalent to 11.3 mg./m³ for DM, 6.3 mg./l. for CN, 9.3 mg./l. for EA 1778, and 7.7 mg./l. for EA 1779.

(C) DM caused minor symptoms during exposure; the chief one was a burning sensation in the airway. Upon exposure to fresh air, these symptoms were accentuated and new symptoms, including salivation, severe coughing and sneezing, became evident, persisting up to 2 hours. There was one severe reaction consisting of face flushing, trembling, profuse sweating, severe pain in the chest, and uncontrollable coughing. This lasted 20 to 25 minutes. The subject did not recover fully for several hours. One person constantly developed laryngitis and another had pain in the teeth. Signs of physical examination were negative, only a slight to moderate conjunctivitis, lasting 5 to 20 minutes.

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(C) EA 1778 produced a burning sensation in the nose with rhinorrhea, burning of the trachea which produced coughing; and occasionally burning of eyes with lacrimation. The coughing sometimes became intolerable, especially after oral breathing. Lacrimation, salivation, and sweating were evident in the total body exposures, and nausea and vomiting occurred in two subjects who had eaten large meals just prior to exposure. Physical examination revealed only a mild transient conjunctivitis; airway resistance was not significantly changed. The agent is nonpersistent and symptoms were rapidly relieved in fresh air.

(C) EA 1779 produced burning of the eyes with lacrimation, irritation of the nose, throat, and chest, coughing, and difficult breathing. The latter symptom was the most severe. During one exposure at a high concentration (80 mg./m³) there was a devastating effect producing casualties within a few seconds with symptoms of vertigo, nausea, vomiting, impending syncope, and inability to open the eyes; these symptoms usually persisted about 5 minutes. Signs of profuse sweating and severe conjunctivitis persisted up to 1 hour. Airway resistance was not significantly altered. One person retained symptoms of anorexia, nausea, and malaise for over 24 hours.

(C) Safety factors for the riot control agents were calculated as follows:

Minimum Lethal Ct in the most sensitive animals = Safety Factor
Effective Ct50 in man (t = 1 min or less)

One minute exposures were used in all calculations although some exposures were terminated in 20 seconds. The values are shown in Table 3.

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TABLE 3 (C)

Safety Factors for Riot Control Agents

Agent	HL CL Animals mg.min./m ³	Effective Ct50 min mg.min./m ³	Safety Factor
EA 1778	10,000	>50	<200
EA 1779	6,700	10 - 20	440
DM	1,000	>100	410

The safety factors indicate that EA 1779 could be used with greater safety than the other agents mentioned.

(C) Of the individual agents, EA 1779 is the most potent and the fastest acting in minimal effective doses. It has the widest margin of safety, based on the ratio between the minimum lethal concentration in the most sensitive species of animal and the effective dose in man. It has the limitation that the incapacitating effects disappear after a few minutes in fresh air. Volunteers have willingly submitted to re-exposure at concentrations of 8 to 16 mg./m³ (1 to 2 ppm).

(C) Tests are in progress to determine the necessary concentration and Ct of DM to produce persistent physiological effects. This Ct appears to be between 100 to 200 mg.min./m³

Mixtures of Riot Control Agents

(C) Sixteen unprotected men were exposed to an aerosol containing 0.5 to 1 ppm each of EA 1779 and DM. This aerosol was intolerable to all men within 20 to 55 seconds. They were incapacitated when emerging from the cloud. All recovered in less than 5 minutes. None suffered persistent or delayed effects. Although reluctant, all were willing to be re-exposed. Ten men carrying protective masks were placed in the wind

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tunnel. When the aerosol was detected they were able to don and continue wearing the masks. Five men carrying protective masks ran in fresh air until they were breathing heavily. They ran into the EA 1779-DM aerosol while hyperventilating. All were able to don and continue wearing the mask. Lack of persistent signs after exposure to an aerosol containing 1 ppm each of EA 1779 and DM is in disagreement with British data. The willingness to be re-exposed to effective concentrations of EA 1779 also differs from British findings. The American volunteers were unselected men who were collected from various Army installations. They had no special training in chemical warfare discipline.

(C) Directorate of Medical Research plans to continue a study of mixtures of EA 1779 and DM. The objective is to obtain an aerosol which will have the speed and effectiveness of EA 1779 and the persistency of DM. It is further hoped that EA 1779 might act as a safety valve and prevent overexposure to the more toxic DM. This would make an ideal agent. Indications at this state of development indicate that an aerosol of 1 part EA 1779 and 10 to 15 parts DM might be required. There is the possibility that the hoped for combination is not possible.

(C) If a suitable mixture is not obtainable then EA 1779 used alone would be the most effective and fastest acting riot control or incapacitating agent available for use against unprotected troops. The limitation of duration of action could be overcome by continued dispersion. This agent should be used in low concentration, 1 to 2 ppm. At this concentration the cloud is invisible to the naked eye. It appears that the effectiveness of this agent would be neutralized by protective masks.

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